Improving Shrub and Grass Fuel Maps using Remotely Sensed Data to Support Fire Risk Assessments

- PI: Jim Vogelmann, USGS-EROS
- Team: Todd Hawbaker, USGS; Hua Shi, InuTeq/USGS-EROS; Matt Reeves, USFS; Ray Dittmeier, SGT/USGS-EROS
- Partner: LANDFIRE
- Project summary: Shrub and grassland ecosystems are prone to fire events, but we have not been able to characterize them very well. Our primary objectives are to: (1) Improve upon shrub and grassland mapping for fire applications; (2) Develop intra-seasonal fuel data sets in shrub and grassland areas; (3) Determine how improvements in shrub and grassland data layers improve fire behavior model results.
- Earth Observations applied: We are using a combination of Landsat and MODIS data, augmented with data collected in the field.

Applied Sciences Program

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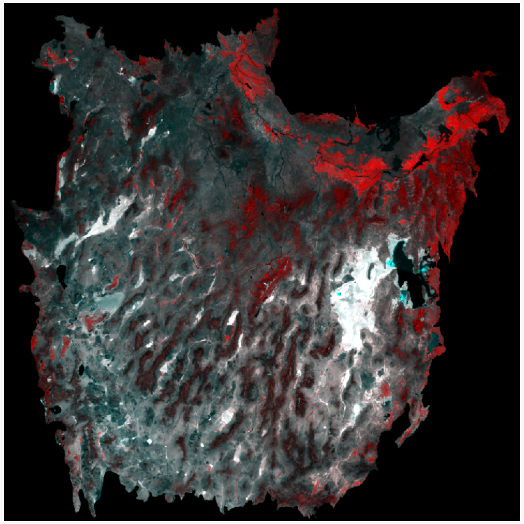
Co-I's: Todd Hawbaker (USGS), Matt Reeves (USFS), Hua Shi (InuTeq/USGS), Ray Dittmeier (SGT/USGS)

Wildland Fire Program
ACTIVE PROJECT
February 28, 2017

Purpose and Objective

Shrub and grassland ecosystems are prone to fire events, but we have not been able to characterize them very well. Our primary objectives are to: (1) Improve upon shrub and grassland mapping for fire applications; (2) Develop intra-seasonal fuel data sets in shrub and grassland areas; (3) Determine how improvements in shrub and grassland data layers improve fire behavior model results

Societal Benefit Area(s): Disasters, Ecosystems, Climate
Geographic Focus: Western US
Targeted End-Users: Fire Managers, LANDFIRE



STARFM June 'Median' mosaic based upon use of 17 individual June mosaics from 2000–2016.

Approach

We are using optical remote sensing to characterize intra- and inter-annual fuel conditions in shrub and grasslands within the Great Basin. The differentials in greenness between spring and late summer are indicative of fire risk, with higher differentials equating to higher risk. We are using STARFM to integrate high spatial resolution Landsat data with high temporal frequency MODIS data. Satellite-derived NDVI data will be related to biomass, which is desired by the fire community, and this will provide information of burnable fuels. Field data have been collected and are being analyzed to help develop the biomass data layers, and ecological and biogeochemical modeling will be used to assess the fuel products that are developed. Our primary target groups of this work include LANDFIRE and other fire management and assessment groups.

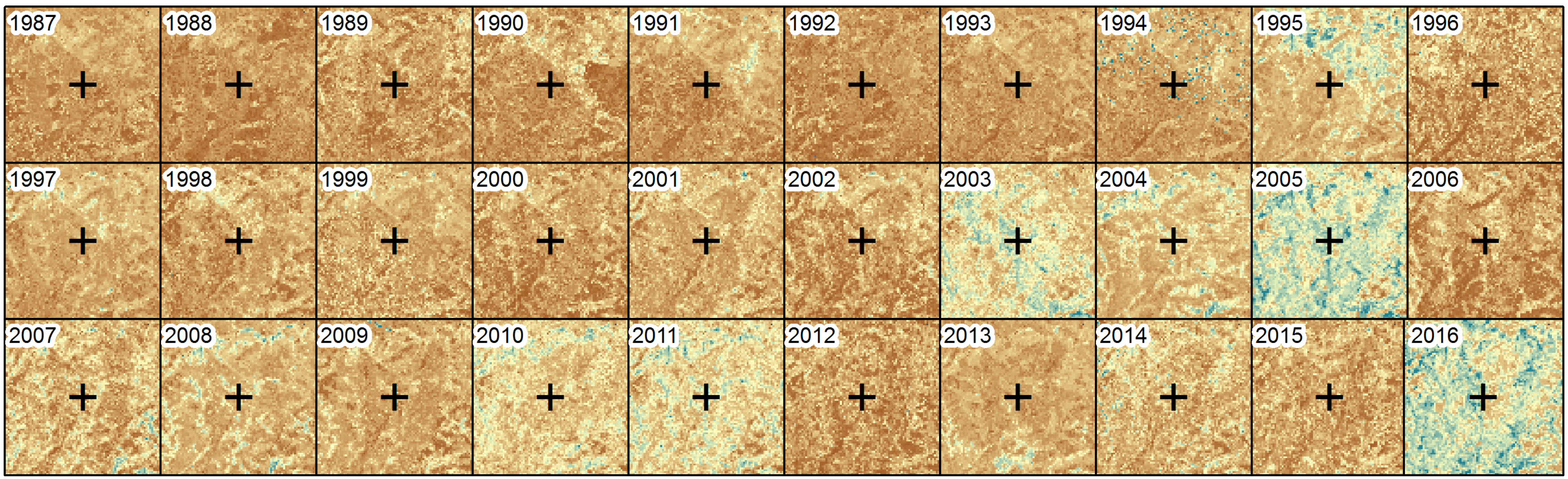
Key Milestones

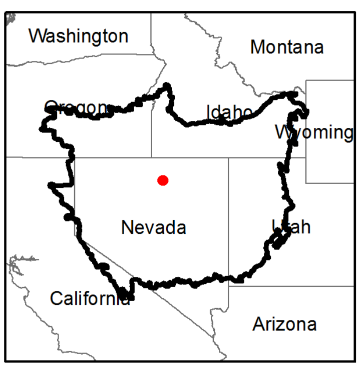
Milestone Statement	Date
Conduct data mining research to determine relationship among remote sensing data, fires, and climate variables in Great Basin.	09/15
Collect biomass data (over 2 field seasons) and integrate with remotely sensed data to generate biomass estimates for the Great Basin.	10/16
Improve upon STARFM modeling to facilitate integration of MODIS and Landsat data for generating seasonal fuel estimates	09/16
Operationally generate western US shrub and grassland seasonal fuel assessments	09/17

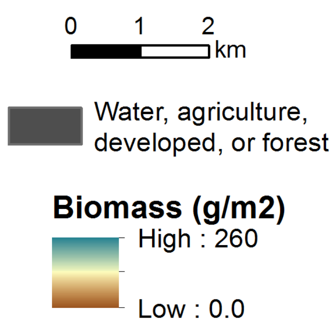
$ARL_{Start} = 1$ $ARL_{Most\ Recent} = 6$ $ARL_{Goal} = 9$

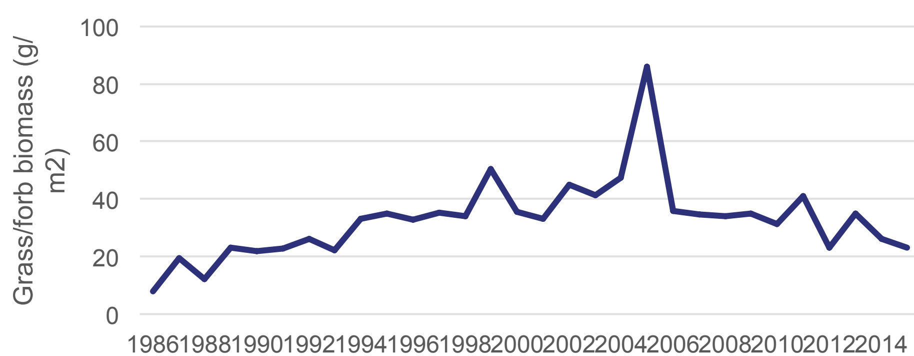
Biggest Achievement: 30-years of biomass!

Random forest model: ln(herbaceous biomass+1) = max($NDVI_{year=0}$) + sd(spring $NDVI_{year\text{-}1\ to\ year\text{-}3}$) + elevation
R^2 (train/test) = 0.92 / 0.39
RMSE (train/test) = 1.5 g/m^2 / 2.7 g/m^2 or 5% / 9% of mean biomass (30.9 g/m^2)





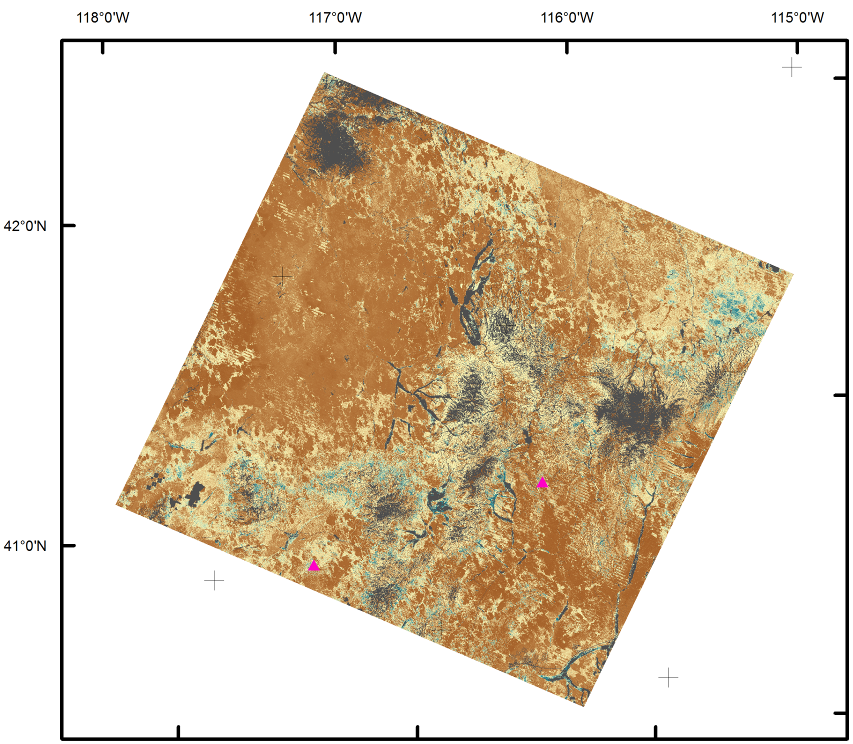




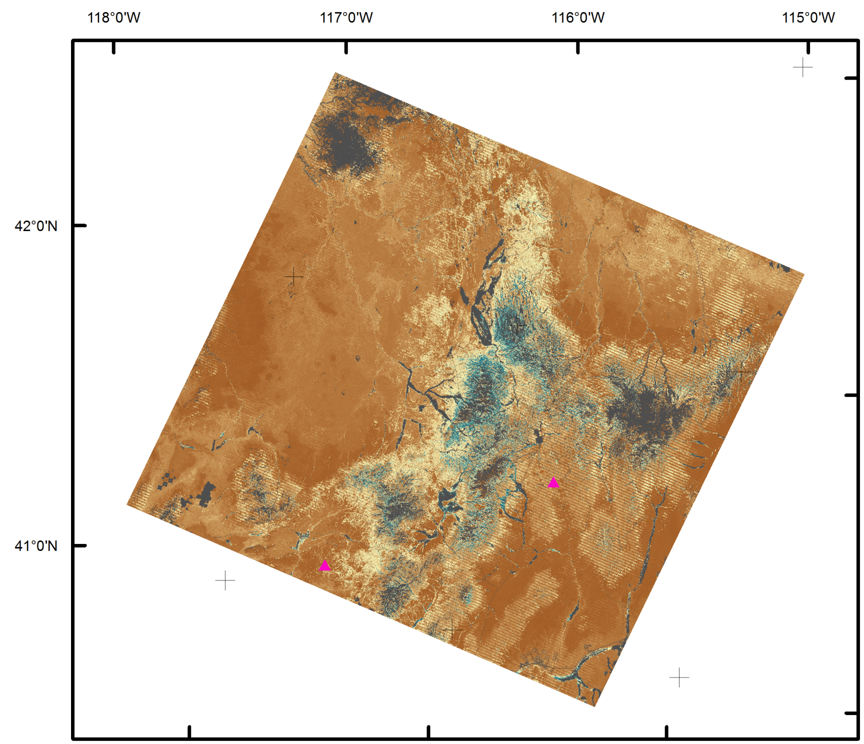
Biggest Achievement: 30-years of biomass!

Path 41 / Row 31, grass/herbaceous biomass

2011



2012



Grass biomass (g/m2)

High : 260

Low: 0

0 25 50 75 km

Path/row polygon

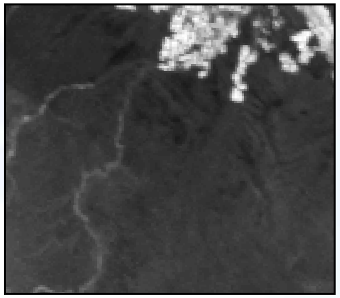
Water, ag, developed, or forest

Biggest Achievement: 17-years of STARFM!

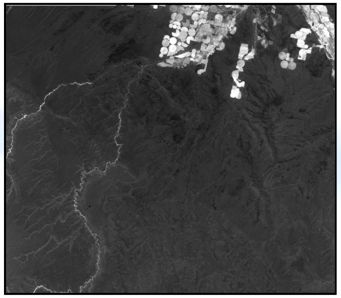
Next steps:

- Incorporate STARFM
- Monthly instead of annual biomass for 2000-2016

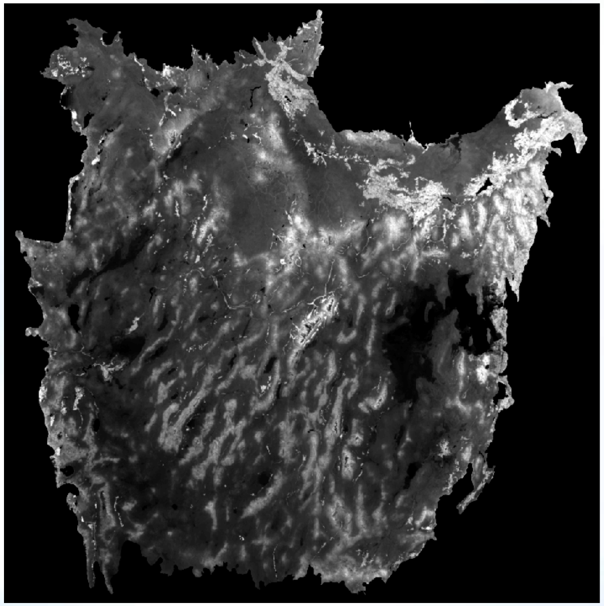
June NDVI



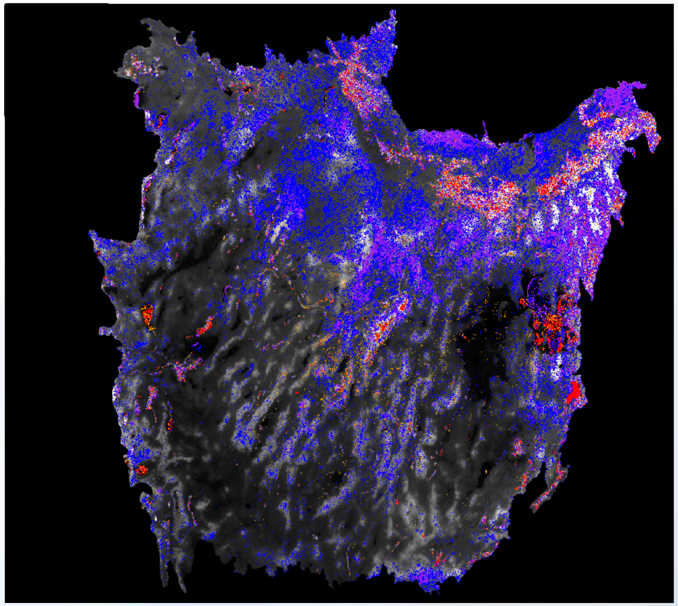
EMODIS*



STARFM



Median June NDVI based on 17 years (2000-2016) of STARFM data.



June 2007 - This was a dry year. Blue and purple is less green than usual.

Improving Shrub and Grass Fuel Maps
J. Vogelmann, USGS

Challenges:

- Mapping shrub biomass over time
- Can fit random forest models that look reasonable:

Landsat-based random forest model:

ln(shrub biomass+1) ~ elevation +

$sd(NDVI_{\text{year-1 to year-3}})$ +

$sd(\text{spring } NDVI_{\text{year-1 to year-3}})$ +

$mean(\text{dormant } NDVI_{\text{year=0}})$ +

$max(\text{winter } NDVI_{\text{year-1 to year-3}})$

R^2 (train/test) = 0.91 / 0.32

RMSE (train/test) = 1.0 g/m^2 / 5.6 g/m^2 or

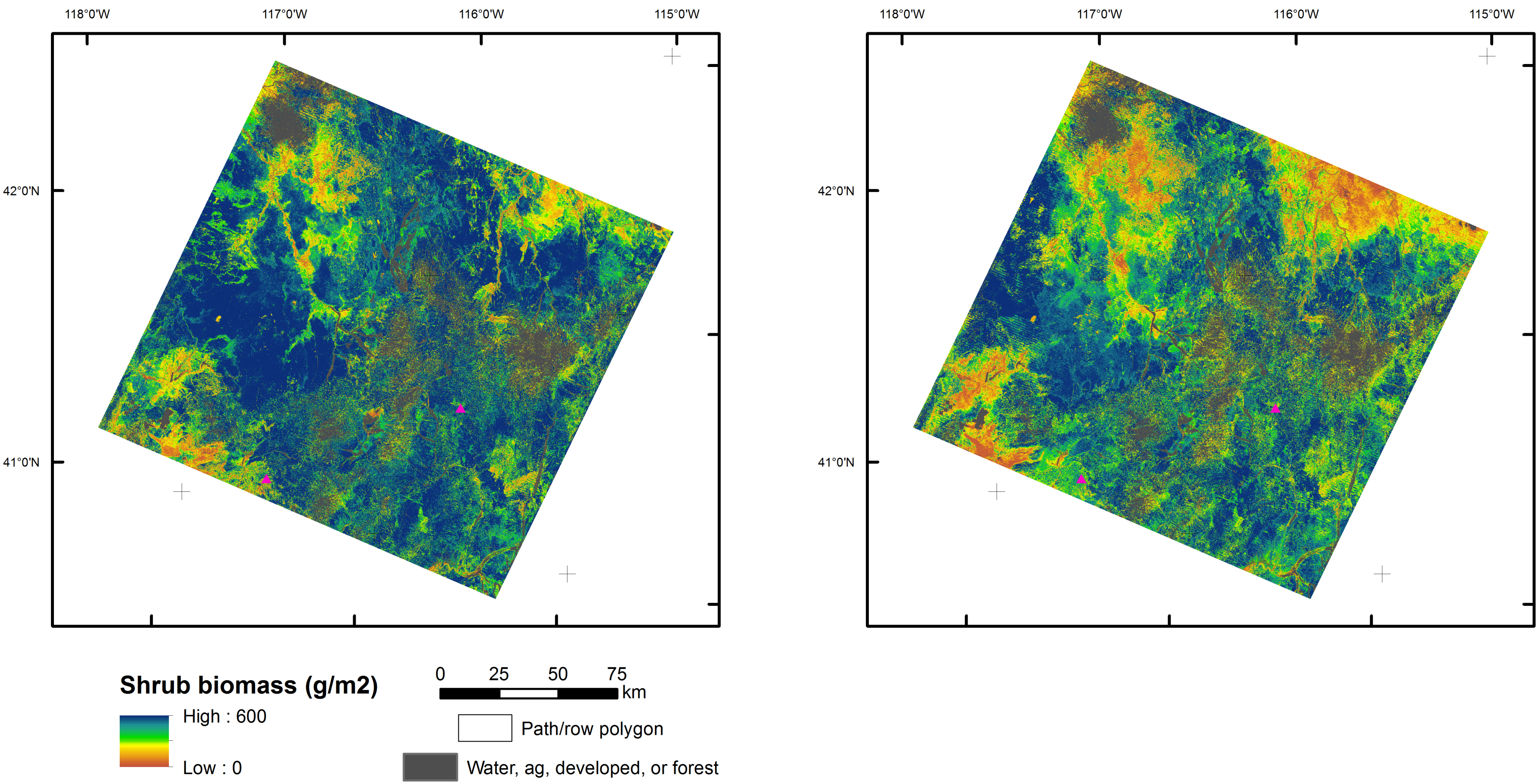
2% / 8% of average shrub biomass (63.7 g/m^2)

Improving Shrub and Grass Fuel Maps
J. Vogelmann, USGS

Challenges:

- Predictions have unreasonable year-to-year variability.

2004 2005



PI Overall Assessment: Current Status

Signs of Positive Progress

1)Completed 2 year campaign to collect field data

2)Related field data to imagery – we can translate surface reflectance to produce biomass products usable by the LANDFIRE Fuels Team

3)Code to train and apply biomass models is efficient and easy to apply over individual Landsat path/rows or STARFM mosaics

4)STARFM processing completed from 2000–2016

5)Streamlined STARFM code to make it more user friendly

Summary of Challenges; Problems; Objective Analysis

Shrub biomass predictions have unreasonable year-to-year variability

Likely an effect of inter-annual variability in cloud and snow cover in dormant seasons

Potential solutions:

1. Identify different predictors,
2. Use STARFM products, or
3. Use intermediate outputs of CCDC algorithm

Overall Assessment

We have made good progress, but much work remains.
Critical steps include mapping biomass, publications, and LANDFIRE transition.

PI Assessment: Transition Plan (1 of 4)

Project end goals and steps remaining:

1. Finalize Landsat shrub biomass models
2. Construct STARFM biomass models
3. Transition to LANDFIRE:
   - Code for data production (STARFM)
   - Biomass model training (from field data)
   - Biomass model predictions (from Landsat or STARFM data)
4. Integrate data and models into Rangeland Vegetation Simulator
5. Complete planned manuscripts

PI Assessment: Transition Plan (2 of 4)

STARFM:

- Minor code changes are needed
- Will be provided to LANDFIRE team along with a user's guide

Biomass models:

- Python code to train and apply random forest models nearly ready to go - needs final set of predictors

Rangeland Vegetation Simulator (RVS):

- Can incorporate shrub/grass biomass relationships and remotely sensed inputs

LANDFIRE transition

- Meeting next week at EROS to continue discussions

PI Assessment: Transition Plan (3 of 4)

Budget:

•Funds planned for FY17 spent by the end of summer − mostly salary

•Work will continue after funds are depleted

- Manuscript revisions
- LANDFIRE transition

•Do we need a no-cost extension for this?

PI Overall Assessment: Transition (4 of 4)

Remaining steps:

- Shrub biomass models
- Linking biomass to STARFM
- Refining RVS
- Transition to LANDFIRE

Originally planned on producing data and tools for shrub and grasslands in the western U.S.

Field data is a limiting factor and LANDFIRE doesn't have the resources to launch a field campaign

Need to leverage field-based efforts in other agencies better, such as BLM's Assessment, Inventory, and Monitoring (AIM) data

Endpoint: to equip the LANDFIRE Fuels Team with data and tools to monitor biomass/fuels in the Great Basin

ARL_{Start} = 1 **$ARL_{Most\ Recent}$** = 6 **ARL_{Goal}** = 9

PI Overall Assessment: Impact

Honest Opinion

We're on the verge of producing and delivering annual and seasonal maps of biomass for the Great Basin.

These maps will help us to better understand variability in fire behavior and effects, and how biomass has responded to climate and other drivers of change.

Project's Impact/Potential as an Analogy

We've assembled the ingredients and mixed the dough…

…but still have to bake and deliver the cookies.

Photos from http://www.cookingforengineers.com/

Relevant Publications, Awards, Accomplishments

Short papers and presentations:

- Reeves, M.; F. Leonardo. 2016. The Rangeland Vegetation Simulator: A user-driven system for quantifying production, succession, disturbance and fuels in non-forest environments. In: A. Iwaasa, H.A. Lardner, M. Schellenberg, W. Willms, and K. Larson eds. Proceedings of the 10th International Rangelands Congress: The Future Management of Grazing and Wild Lands in a High-Tech World; 16-22 July, 2016; Saskatoon, Saskatchewan. The International Rangeland Congress. p. 1062-1063.
- Reeves, M., P. Ford, L. Frid, D. Augustine, J. Derner. 2016. A prototype application of state and transition simulation modeling in support of grassland management. In: A. Iwaasa, H.A. Lardner, M. Schellenberg, W. Willms, and K. Larson eds. Proceedings of the 10th International Rangelands Congress: The Future Management of Grazing and Wild Lands in a High-Tech World; 16-22 July, 2016; Saskatoon, Saskatchewan. The International Rangeland Congress. p. 1105-1107.
- Shi, H., J. Vogelmann, T. Hawbaker, M. Reeves, and R. Dittmeier, Mapping fuel loads and dynamics in rangelands using multi-sensor data in the Great Basin, USA, poster presentation at 2016 AGU Fall Meeting, San Francisco, 12-16 December, 2016.

Anticipated journal manuscripts:

- Hawbaker et al., Monitoring long-term trends in biomass across the Great Basin, to be submitted to biomass special issue of Remote Sensing (spring, 2017).
- Shi et al., Mapping seasonal and inter-annual shrub and grass change in the Great Basin using merged Landsat and MODIS data, to be submitted to Remote Sensing (anticipated submission by summer, 2017)
- Reeves et al., A spatially explicit approach for quantifying shrub and grass fuel loadings in U.S. rangelands, to be submitted to a fire journal (probably by summer, 2017).

No cookies, but happy to answer questions

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